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Indian Standard

SPECIFICATION FOR IF AND RF TRANSFORMERS AND INDUCTORS (COILS)

PART I GENERAL REQUIREMENTS AND TESTS

(First Reprint OCTOBER 1995)

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Indian Standard

SPECIFICATION FOR IF AND RF TRANSFORMERS AND INDUCTORS (COILS)

PART I GENERAL REQUIREMENTS AND TESTS

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Indian Standard

SPECIFICATION FOR IF AND RF TRANSFORMERS AND INDUCTORS (COILS)

PART I GENERAL REQUIREMENTS AND TESTS

0. FOREWORD

0.1 This Indian Standard (Part I) was adopted by the Indian Standards Institution on 28 May 1982, after the draft finalized by the Transformers and Inductors for Electronics Equipment Sectional Committee had been approved by the Electronics and Telecommunication Division Council.

0.2 IS : 1519-1969* does not cover the professional grade intermediate frequency (IF) and radio frequency (RF) transformers and inductors (coils). The Sectional Committee, therefore, decided to cover the requirements and tests for professional grade IF and RF transformers and inductors (coils) in addition to those for existing types covered by IS : 1512-1969* in a series of standards and to supersede IS : 1512-1969* by this series. This standard forms (Part I) of the proposed series.

0.3 The object of this standard is to establish uniform requirements for the mechanical properties of IF and RF transformers and inductors (coils) and their tolerance of climatic conditions to describe test methods and to classify these methods into groups according to environmental conditions in which they are performed.

0.4 In the case of components like IF and RF transformers and inductors (coils), the performance requirements are largely related to the design of the perticular circuit for which they are intended and it would, therefore, be difficult to lay down at this stage a uniform set of requirements, irrespective of the equipment design. Therefore, this standard (Part I) covers only general requirements and testing methods, leaving the specific performance requirements to be specified while the intending purchaser furnishes additional details of the components. At a later stage, it may be possible to specify performance requirements and, in that case, these

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*Tests and general requirements for IF transformers and RF coils (*first revision*).

would be covered in subsequent parts of this series. A list of items on which the purchaser will have to specify the requirements is given in Appendix A.

0.5 This standard lays down a single method of measurement for each characteristic. It is, however, not intended to exclude other alternative methods of measurement for which necessary equipment may be available.

0.6 While preparing this standard assistance has been derived from JSS 54600 ' General requirements for intermediate frequency, radio frequency, transformers and coils ' issued by the Ministry of Defence.

0.7 For the purpose of deciding whether a particular requirement of this standard is complied with, the final value, observed or calculated, expressing the result of a test, shall be rounded off in accordance with IS : 2-1960*. The number of significant places retained in the rounded off value should be the same as that of the specified value in this standard.

1. SCOPE

1.1 This standard (Part I) covers general requirements and tests applicable to IF and RF transformers and inductors (coils) used in electronic and telecommunication equipment.

1.1.1 The following components are mainly covered by this standard:

a) *IF and RF transformers* — Single tuned or double tuned, and

b) *IF and RF inductors* (*coils*) — Coils of single or double winding meant for use in tuned circuits, such as antenna coils and oscillator coils.

2. TERMINOLOGY

2.0 For the purpose of this standard, the following definitions shall apply.

2.1 Type Tests — Tests carried out to prove conformity with the requirements of this specification. These are intended to prove the general qualities and design of a particular type of IF transformer or RF coil.

2.2 Acceptance Tests — Tests carried out on samples of transformers or coils selected from a lot for the purpose of acceptance of the lot.

2.2.1 *Lot* — All transformers or coils of the same grade and rating, manufactured by the same factory, during the same period.

2.3 Routine Tests — Tests carried out on each transformer or coil to check the requirements which are likely to vary during production.

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*Rules for rounding off numerical values (*revised*).

2.4 Inductor (Coils) — An electromagnetic device consisting of a conductor wound in cylindrical or spiral form, or in a variation of these forms, to obtain a concentrated magnetic field parallel to the axis of the coil.

2.5 Coil Assembly — Two or more coils on a common mounting or mounted on each other.

2.6 Distributed Capacitance of a Coil — The resultant of capacitances between turns within the coil. It may be determined by measuring the self-resonant frequency of the coil.

2.7 Equivalent Series Resistance (ESR) — The real (power consuming) portion of the coil impedance.

2.8 Inductance Tolerance — The permissible deviation of the manufactured inductance value usually expressed in percent, from the specified nominal inductance value at standard (or stated) atmospheric conditions.

2.9 Intermediate Frequency Transformer — It consists of two or more windings designed to pass a specific band of radio frequencies which results from heterodyning a local oscillator signal with a radio frequency signal.

2.10 Insulation Working Voltage — The maximum instantaneous voltage stress that may appear under normal rated operation across the insulation being considered. This insulation may be between windings or between a winding and the case or core.

2.11 Insertion Loss — The ratio of the power delivered to the land before insertion of the transformer to the power delivered to the load after insertion of the transformer.

2.12 Parallel Resonant Frequency — The frequency at which the input impedance is a maximum (only approximately true when Q is 10 or above.)

2.13 Quality Factor — The factor Q expresses the ratio of reactance to effective resistance of a circuit element.

2.14 Radio Frequency Coil — Designed to develop inductive reactance at radio frequencies.

2.15 Radio Frequency Transformer — A transformer so designed as to operate at a frequency range above 20 kHz.

2.16 Resonant Frequency — The frequency (or frequencies) of a component, circuit, or system where the capacitive and inductive reactances are exactly equal.

2.17 Series Resonant Frequency — The frequency at which the input impedance of a circuit is a minimum.

2.18 Transformer Assembly — Two or more separate transformers on a common mounting or mounted on each other.

2.19 Grade — The grade indicates the following environmental characteristics:

a) Grade 1 — Resistant to immersion and humidity,
b) Grade 2 — Resistant to humidity, and
c) Grade 3 — For use in sealed assemblies.

3. CLIMATIC CATEGORIES AND TYPES

3.1 Climatic Categories — The IF and RF transformers and coils shall belong to one of the following three categories based on their ability to withstand the climatic severities:

Climatic Test	*Category 1*	*Category 2*	*Category 3*
Dry heat (Duration : 16 hours)	+100°C	+85°C	+70°C
Cold	−55°C	−40°C	−10°C
Damp heat (steady state)	56 days	56 days	21 days
Damp heat (cyclic)	6 cycles	6 cycles	2 cycles
Rapid change of temperature	+100 to −55°C	+85 to −40°C	Not applicable
Low airpressure	4·4 kPa	30 kPa	60 kPa

NOTE 1 — A recovery period of 24 hours after the damp heat accelerated and damp heat long term tests is necessary for Category 3 components.

NOTE 2 — In special cases, where the above categories are not applicable, other combinations of severities may be agreed to, provided such severities are chosen from IS : 9000 (Part I)-1977*.

4. MATERIALS, CONSTRUCTION AND WORKMANSHIP

4.1 General — The materials, construction and finishes shall be specified in the relevant detail specification, as they are mandatory. The transformers and inductors shall be manufactured and processed in a careful workmanlike manner, in accordance with good design and sound engineering practice. The transformers and coils shall be uniform in quality and shall be free from cracks, rough edges, loose mountings, broken leads, and other defects that may affect life, serviceability and/or appearance.

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*Basic environmental testing procedures for electronic and electrical items : Part I General.

4.2 Materials — The IF and RF transformers and inductors shall be constructed from materials which shall be free from flaws and other defects and shall, as far as practicable, conform to the relevant detail specification. In so far as practicable, materials used in the construction of transformers and inductors shall be non-explosive, non-flammable, not susceptible to out-gassing, non-nutrient to corrosive atmosphere and shall meet the requirements of this specification.

4.3 Terminations

4.3.1 *Solder-Type Terminations*—Solder termination may be of any shape. The height of the solder terminal shall be considered as the maximum distance from the terminal mounting surface to the highest point, including the additional height obtained if semiflexible terminals are straightened. (It is not intended that the 'hook' in the hook-type terminal be straightened from its normal hooked position.)

4.3.2 *Pin-Type Terminations for Printed Circuit Applications*—The preferred diameter for the terminal pins of printed circuit transformers is 0·7 mm. The grid metrix shall conform to a 2·54 mm grid with centres to a tolerance of ± 0·5 mm. Uninsulated solid wire terminals not greater than 25·4 mm in length shall be considered to be pins.

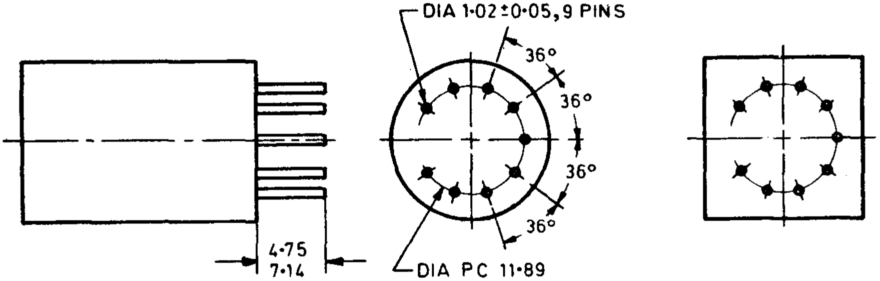
4.3.3 *Pin-Type Terminations for Electron Tube Type Sockets* — Pins for use with electron tube type sockets shall conform with standard 7 pin base E7-1 or standard 9 pin base E9-1, as shown in Fig. 1. Uninsulated solid wire terminals not greater than 25·4 mm in length shall be considered to be pins.

4.3.4 *Screw-Type Terminations*—When specified, external screw terminals shall be supplied with 2 nuts, 2 flat washers, and one lock washer. For Grades 1 and 2 transformers, the height of the terminal assembly shall be the distance from the free end of the screw to the terminal mounting surface. The type of terminal, size of screw thread and the exposed length ± 1 6 mm shall be as specified (for example, 0·164 UNC 9·54 mm long).

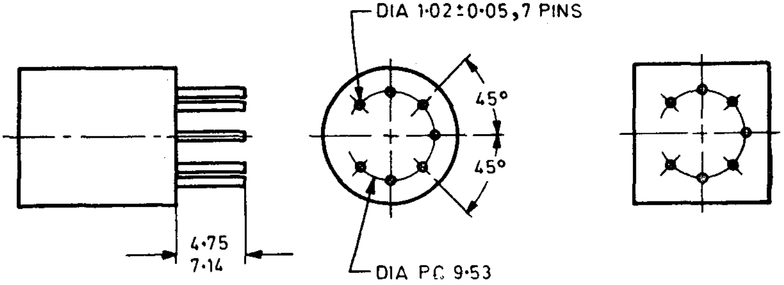
4.3.5 *Solderable/Weldable Lead Terminations* — The terminations shall be tin-lead coated copper wire having the composition and plating given below :

Chemical Composition — The chemical composition of the copper wire shall be as follows:

Copper plus silver trace	99·900 percent, *Min*
Oxygen	0·015 percent, *Max*
Silver	0·052 percent, *Max*
Phosphorous	0·015 percent, *Max*
Total of all impurities	0·100 percent, *Max*



STANDARD 9-PIN BUTTON BASE E 9-1



STANDARD 7-PIN BUTTON BASE E 7-1

All dimensions in millimetres.

FIG. 1 PIN-TYPE TERMINATIONS FOR ELECTRON TUBE TYPE SOCKETS

4.4 Winding Ends — The ends and end turns of layer-wound coil and the finish turns of universal-wound coils shall be secured in such a manner as to anchor them securely in place. The length of leads from windings shall be as short as practicable and, when necessary, shall be supported to prevent vibration. The termination of element to terminal shall not depend on solder or welding alone to attain mechanical strength.

4.5 Design and Construction — Transformers and coils shall be of the design, construction and physical dimensions as specified.

4.5.1 *Threaded Parts* — Threaded parts shall be of corrosion-resistant material or shall be protected against corrosion.

4.5.2 *Screw, Nuts and Washers* — All mountings and terminal screws, nuts and washers shall be of corrosion-resistant material or shall be protected against corrosion.

4.5.3 *Engagement of Threaded Parts* — All threaded parts shall be engaged by at least three full threads.

4.5.4 *External Can Shields (When Applicable)* — External can shields shall be so constructed that they can be effectively mounted mechanically and grounded electrically by their normal mounting means.

4.6 Magnet Wire — Magnet wires shall be of types and sizes as specified in IS: 4800 Series dealing with enamelled round winding wires.

4.7 Resistors and Capacitors — Resistors and capacitors shall be in accordance with Indian Standards, except when the size, design and environmental characteristics of the transformer prohibit this. They will be of the same grade and category as required for the component.

4.8 Solder and Soldering Flux — The solder used shall be soft solder conforming to Grade Sn 60 of IS : 193-1977* and the soldering flux shall be 25 percent by weight of water white rosin and 75 percent by weight of 99 percent isopropyl alcohol.

5. MARKING

5.1 Each transformer or coil shall be indelibly and clearly marked with the following information:

a) Manufacturer's name or trade mark,

b) Type designation, and

c) Identification of terminations (*see* Note).

NOTE — A circuit diagram of the transformer or coil with appropriate markings and connections shall also be made available with the component.

5.2 In addition to the markings specified in **5.1**, the following information shall be provided either on the carton or in the catalogue along with the circuit diagram:

a) Nominal frequency of operation or frequency range of operation;

b) Inductances of the individual windings;

c) Q factor (of the tuned circuit or of the individual winding);

d) – 3 dB bandwidth;

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*Specification for soft solder (*third revision*).

e) Selectivity:
   1) For amplitude modulation : as response at ± 5 kHz at ± 10 kHz or at any other frequency range off resonance, and
   2) For frequency modulation : as response at ± 200 kHz or at any other frequency range off resonance;

f) Transfer voltage ratio (gain factor);

g) Factor *KQ* with recommended external impedances for double tuned IF transformers;

h) Factor *k* for aerial coils;

j) Self-capacitance for IF and RF coils or recommended external capacitance values (minimum and maximum values);

k) Overall dimensions, grade and category;

m) Any other information as agreed; and

n) Country of manufacture.

5.2.1 Any additional marking on the component or its carton shall be so applied as not to cause confusion.

5.2.2 The transformer or coil or its carton may also be marked with the ISI Certification Mark.

NOTE — The use of the ISI Certification Mark is governed by the provisions of the Indian Standards Institution (Certification Marks) Act and the Rules and Regulations made thereunder. The ISI Mark on products covered by an Indian Standard conveys the assurance that they have been produced to comply with the requirements of that standard under a well-defined system of inspection, testing and quality control which is devised and supervised by ISI and operated by the producer. ISI marked products are also continuously checked by ISI for conformity to that standard as a further safeguard. Details of conditions under which a licence for the use of the ISI Certification Mark may be granted to manufacturers or processors, may be obtained from the Indian Standards Institution.

6. COLOUR CODE

6.1 For Leads — The standard colour code for leads of IF transformers or RF coils shall be as follows:

Circuit Function	*Colour*
a) *Valve Electrodes*:	
Anode	Blue
Cathode	Yellow
Control grid	Green
Screen grid	Orange
Suppressor grid (or modulator grid)	Grey

Circuit Function	*Colour*
b) *Transistor Electrodes*:	
Collector	Blue
Emitter	Yellow
Base	Green
c) *dc Supplies*:	
Chassis	Black
Positive to chassis	Red
Negative to chassis	Violet
d) *Terminals to special connections*	As agreed to between the purchaser and the manufacturer

NOTE — Wherever it is not practicable to use leads or terminals of the recommended colours, they may be suitably coated with paint corresponding to the appropriate colour code.

6.2 For Cylindrical Coils — Cylindrical coils shall be marked with four coloured bands of equal width, three indicating the inductance in microhenries and the fourth band indicating the tolerance in percent. Colour code shall be in accordance with the colour code shown in Table 1. When either the first or second of the three bands is gold, this band shall represent the decimal point for inductance values less than 10, and the other two bands shall represent significant figures. For inductance value of 10 or more, the first two bands shall represent significant figures, and the third band shall represent the multiplier. When specified for small units, dots may be used instead of bands. Typical colour code for units with inductance values less than 10 and for 10 or greater is shown in Fig. 2. The marking shall be legible after completion of each examination or test.

6.3 Terminal Identification — Unless otherwise specified, terminals shall be identified by appropriate numbers or, where space does not permit numbering, by colour code in accordance with Table 2.

7. TESTS

7.1 General Conditions for Tests

7.1.1 *General* — The tests shall be carried out on the components as received from the manufacturer or supplier. In no case shall the contact parts be cleaned or otherwise prepared prior to the tests, unless explicitly so agreed.

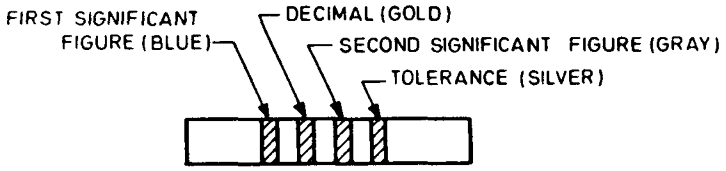
TABLE 1 COLOUR CODE

(*Clause* 6.2)

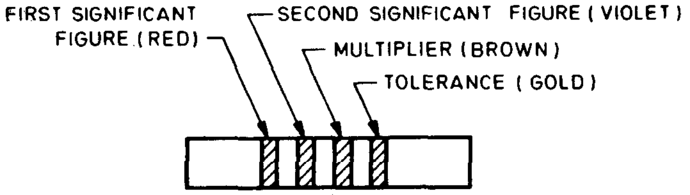
Colour	Significant Figure	Multiplier*	Inductance Tolerance (Percent)
(1)	(2)	(3)	(4)
Black	0	1	—
Brown	1	10	—
Red	2	100	—
Orange	3	1 000	± 3
Yellow	4	—	—
Green	5	—	—
Blue	6	—	—
Violet	7	—	—
Grey	8	—	—
White	9	—	—
None†	—	—	± 20
Silver	—	—	± 10
Gold	Decimal point	—	± 5

*The multiplier is the factor by which the two significant figures are multiplied to yield the nominal inductance value.

†Indicates body colour.


FIRST SIGNIFICANT FIGURE (BLUE)
DECIMAL (GOLD)
SECOND SIGNIFICANT FIGURE (GRAY)
TOLERANCE (SILVER)

6·8 MICROHENRIES ±10 PERCENT


FIRST SIGNIFICANT FIGURE (RED)
SECOND SIGNIFICANT FIGURE (VIOLET)
MULTIPLIER (BROWN)
TOLERANCE (GOLD)

270 MICROHENRIES ±5 PERCENT

Fig. 2 Typical Colour Code

TABLE 2 TERMINAL COLOUR CODE

(*Clause* 6.3)

COLOUR (1)	NUMBER (2)	COLOUR (1)	NUMBER (2)
Black	0	Green	5
Brown	1	Blue	6
Red	2	Violet	7
Orange	3	Grey	8
Yellow	4	White	9

7.1.2 *Selection of Samples* — The samples for testing shall be so selected as to be representative of each category and rating.

7.1.3 *Atmospheric Conditions for Testing* — Unless otherwise specified, all tests shall be carried out under standard atmospheric conditions specified in IS : 9000 (Part I)-1977*

7.1.4 *Preconditioning* — Before measurements are made, the components shall be stored at the measuring temperature and the relative humidity for a time sufficient to allow the entire component to reach these conditions. The recovery period called for after conditioning is adequate for this purpose.

7.1.5 *Correction to be Applied* — When measurements are made at an ambient temperature other than the specified temperature, the results shall, where necessary, be corrected to the specified temperature. The ambient temperature during the test shall be stated in the test report.

7.1.6 *Drying* — Where drying before measurement is required, it shall be done in accordance with **3.5** of IS : 9000 (Part I)-1977*.

7.1.7 *Other Precautions* — During measurements, the components shall not be exposed to draughts, direct sun-rays or other influences likely to cause errors.

7.2 Classification of Tests

7.2.1 *Type Tests* — The procedure for type approval shall be in accordance with IS : 2612-1965†.

a) *Number of samples* — The number of samples for type tests shall be 12 of each category and rating of the components, unless otherwise specified, stated in the relevant specification.

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*Basic environmental testing procedures for electronic and electrical items : Part I General.

†Recommendation for type approval and sampling procedures for electronic components.

b) *Sequence of type tests* — The sequence of type tests shall be in accordance with Table 3, unless otherwise specified in the relevant specification.

TABLE 3 TYPE TESTS

Group	Number of Specimen	Tests	Clause Number
(1)	(2)	(3)	(4)
0	All	Visual examination	7.3.1
		Dimensions	7.3.3
		Continuity of winding	7.4.11
		DC resistance	7.4.1
		Inductance	7.4.2
		Magnification factor, Q	7.4.3
		Coupling	7.4.4
		Incremental current inductance reduction	7.4.5
		Effective parallel resistance	7.4.6
		Self-resonant frequency	7.4.7
		Impedance	7.4.8
		Bandwidth and gain	7.4.9
		Voltage transfer ratio	7.4.10
		Voltage proof	7.4.12
		Induced voltage	7.4.13
		Insulation resistance	7.4.14
		Overload	7.4.15
		Bandwidth and salectivity	7.4.16
		Factor KQ (for double tuned IF transformer)	7.4.17
		Checking the adjustment facilities	7.4.18
		Sealing (when applicable)	7.5.1
		Immersion	7.5.2
1	3	Core rotation	7·5.7
		Solderability	7.5.3
		Robustness of terminations	7.5.4
		Vibration	7.5.5
		Bump	7.5.6
		Change of temperature	7.8
		Climatic sequence	7.6.1
2	3	Damp heat (steady state)	7.7
3	3	Endurance	7.11
		Flammability	7.13
4	1	Mould growth	7.10
5	1	Temperature rise	7.12
6	1	Salt mist	7.9

7.2.2 *Routine Tests* — The routine tests shall be performed in the following order:

Test	*Clause Number*
a) Visual examination	7.3.1
b) Voltage proof	7.4.12
c) Voltage transfer ratio	7.4.10
d) Factor *KQ* (for double tuned IF transformers and Factor *K* or *Q* for other components as applicable)	7.4.17
e) Sealing test (for sealed type only)	7.5.1

7.2.2.1 If during the routine tests more than 10 percent of the lot fails, the entire lot may be rejected.

7.2.3 *Acceptance Tests* — The acceptance tests shall be carried out on a limited number of samples selected in accordance with the sampling procedure given in IS : 2612-1965* from a lot which has passed the routine tests as specified in 7.2.2.

Two groups of samples shall be selected and each group shall be subjected to the tests specified in the order in Table 4, unless otherwise specified in the individual relevant specification.

TABLE 4 ACCEPTANCE TESTS

TEST (1)	CLAUSE NUMBER (2)	AQL (PERCENT DEFECTIVE) (3)	INSPECTION* LEVEL (4)	D/N† (5)
GROUP A TEST				
Dimensions	7.3.2			
All the electrical tests	7.4	4	II	**N**
GROUP B TEST				
***Subgroup* 1**				
Detail dimensions	7.3.3			
***Subgroup* 2**				
Robustness of termination	7.5.4	4	S3	**D**
Soldering	7.5.3			
Climatic sequences	7.6			

***Sampling plans and procedures for inspection by attributes for electronic items, Doc : LTDC 3 (88)F.**

†D = Destructive; N = Non-destructive.

***Recommendation for type approval and sampling procedures for electronic components.**

7.3 General Tests

7.3.1 *Visual Examination (External)* – Each transformer or inductor (coils) shall be visually examined for conformity to the following:

a) The markings shall be in accordance with 5; and
b) The construction, workmanship, finish, conditions and assembly shall be satisfactory.

There shall be no deterioration in the above features after electrical, mechanical and climatic tests.

7.3.2 *Outline Dimensions* — The outline dimensions shall be checked for compliance with the outline drawings, as specified in the relevant specification or manufacturers' drawings.

7.3.3 *Detail Dimensions* — The components shall be checked for compliance with the drawings specified in the relevant specification or manufacturers' drawings:

a) *For type tests* — The dimensions and materials used shall be in accordance with the relevant specification or manufacturers' drawings. This should be recorded.
b) *For acceptance tests* — The dimensions shall conform to the detail drawings as specified in the relevant specification or supplied by the manufacturer.

7.3.4 *Visual Examination (Internal)* — The components shall be dissembled and examined to verify that materials, internal design, construction, workmanship and finish are in accordance with the requirements of relevant specification or the reqirements specified by the manufacturer.

7.3.5 *Mass* — Six components shall be exmined to verify the mass of the component, if specified in the relevant specification.

7.4 Electrical Tests

7.4.1 *DC Resistance* — The DC resistance shall be measured with a resistance bridge or other suitable test equipment. The test current through the specimens shall be as small as possible considering the sensitivity of the indicating instruments, unless the test current or voltage is specified. When it is important that the temperature of the specimens shall not rise appreciably during the measurement, the test voltage shall be applied uninterruptedly for as short a time as practicable, but in no case for more than 5 seconds, unless otherwise specified. The measurements shall be made at or corrected to 20°C.

NOTE 1 — The current of the measuring instrument shall not cause a saturation effect, when measuring transformers with ferrite cores.

NOTE 2 — DC measurements of ferrite core coils shall be made after inductance, Q, and self-resonant frequency (SRF) are measured because dc affects inductance and Q in testing. Time shall be allowed for return to the initial electrical properties.

The values shall be within the limits as specified in the relevant specification.

7.4.2 *Inductance* — Unless otherwise specified, inductance of each winding or between stated terminals shall be measured at the frequency specified. When true inductance is specified, the test procedure or equivalent listed below shall be used. A calibrated capacitor shall be used to tune the winding to resonance at several frequencies. These points shall describe a straight line of added capacitance, one point of which shall be $\frac{1}{f_0^2}$ as abscissa versus the reciprocal of the frequency square, as ordinate; the true inductance shall be calibrated as:

$$\text{True inductance} = KN$$

where

$$K = \frac{1}{4\pi^2} = 0{\cdot}025\,3,$$

N = Slope of the line representing added capacitance, and

f_0 = Self-resonant frequency of the coil at the abscissa of zero capacity.

The inductance shall be as specified in the relevant specification.

7.4.2.1 *Effective inductance for cylindrical coils (inductance 0·10 to 10 μH inclusive)* — The effective inductance shall be measured using a Q-meter, such as Hewlett Packard Q-meter Model 4342A or equivalent. The frequency dial of the Q-meter shall be calibrated within ± 0·1 percent for the applicable test frequency by any suitable means. The various ranges of inductance shall be tested according to the frequencies given below:

Inductance Range μH	*Test Frequency* MHz
0·10 to 1·0	25·0
Above 1·0 to 10·0	7·9

Allowance shall be made for the internal inductance of the Q-meter and the test fixture as determined in **7.4.2.2.**

7.4.2.2 *Effective inductance* — The effective inductance shall be determined when using a test fixutre such as TF-A or TF-B, as applicable, shown in Fig. 3 and 4 or any suitable fixtures. The appropriate test fixture shall be inserted in the Q-meter coil terminations with the side showing the test fixture letter facing the capacitance terminations. The appropriate shorting bar conforming to Fig. 5 or 6 shall be inserted in the chips of the test fixture in such a manner that the terminals rest firmly against the stops, and the bar is centred between the test fixture terminations. The Q-meter capacitance dial shall be set at 400 pF and the vernier capacitance dial at zero. The Q-meter shall then be resonated, using the frequency dial, until a peak reading is obtained. This frequency shall be monitored in order to obtain an accuracy of 0·1 percent. This resonant frequency value in MHz shall be recorded. The main capacitance dial shall be calibrated periodically in accordance with a routine calibration programme for test equipment. The sum of residual inductance of the Q-meter and the inductance of the test fixture shall be calculated from:

$$L_{cf} = \frac{1}{4\pi^2 f^2 c} - L_{bar}$$

where

L_{cf} = inductance in microhenries of the test fixture and the residual inductance of the Q-meter;

f = frequency in MHz;

c = capacitance in μF; and

L_{bar} = calculated inductance in microhenries of the shorting bar as determined from the following formula:

$$I_{bar} = 0{\cdot}0021 \left(2{\cdot}303 \log 10 \frac{41}{d} - 1 + \mu + \frac{d}{21} \right)$$

where

σ = a quantity as a function of X and is between 0·000 1 and 0·007 which can be considered negligible.

$$X = 0{\cdot}1405\, d\sqrt{\frac{\mu^{f}}{P}}$$

where

d = diameter of cross-section (cm),

μ = permeability of the material of the wire, 1 for brass or copper,

P = volume resistivity of wire in microcentimetres, and

f = frequency in cycles.

After removing the shorting bar from the test fixture, the Q-meter frequency shall be set to the frequencies specified above. The coil under test shall then be inserted in the test fixture in such a manner that the loads are straight and rest firmly against the stops, and the unit is centred between the test fixture terminations. The L-C dial of the Q-meter shall then be turned until the resonance meter indicates a peak reading. The inductance (*Ld*) shall be read directly on the L-C dial, using the inductance scale and the effective inductance of the coil shall be calculated from the formula:

$$L = Ld - L_{cf}$$

where

L = effective inductance in microhenries

Ld = inductance dial reading in microhenries, and

L_{cf} = correction factor for inductance of test fixture and residual inductance of the Q-meter in microhenries.

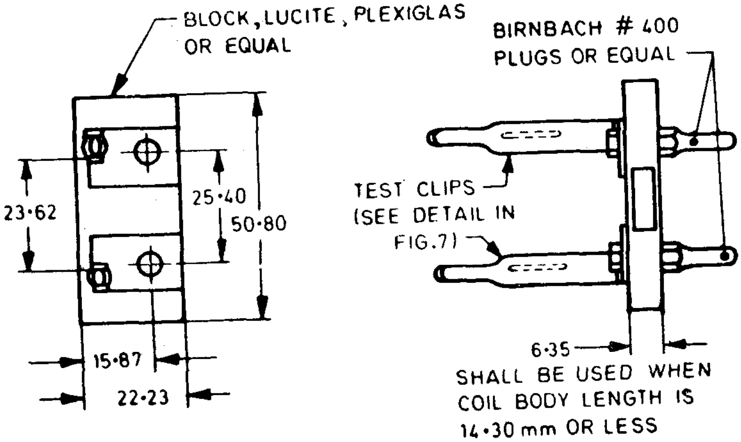
The inductance shall be as specified in the relevant specification.

7.4.2.3 *Effective inductance for cylindrical coils (inductance greater than 10 microhenries)* — The coils shall be tested in accordance with **7.4.2.1** and **7.4.2.2** except that no allowance shall be made for residual inductance of the Q-meter and that of the test fixture. The various ranges of inductance shall be tested according to the frequencies given below:

Inductance Range *µH*	*Test Frequency* *MHz*
Above 10 to 100	2·5
Above 100 to 1 000	0·790
Above 1 000 to 10 000	0·250
Above 10 000 to 100 000	0·079

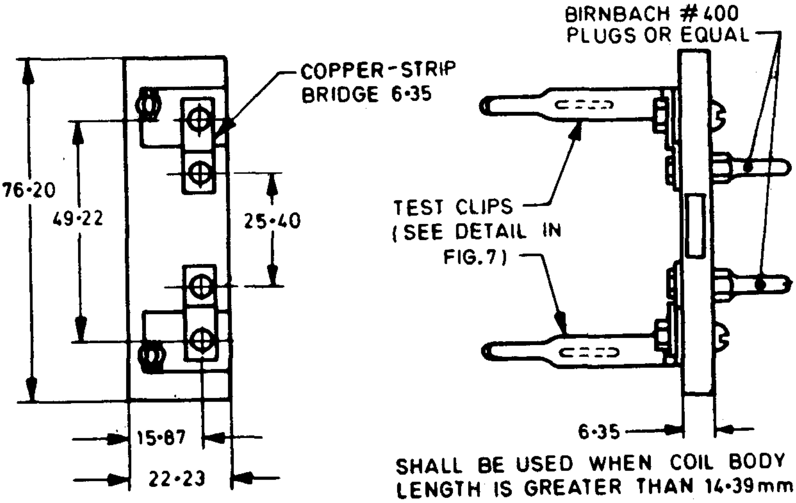
7.4.2.4 *Effective inductance for radial lead coils (inductance 0·10 to 10·0 microhenries inclusive)* — The effective inductance for radial lead coils shall be measured as specified in **7.4.2.2** except that test fixtures TF-C, TF-D or TF-E shown in Fig. 7, or any other suitable device, shall be used. The shorting bar for use with these test fixtures shall be made of 1·02 mm solid copper wire approximately 31·75 mm long. The inductance shall be as specified in the relevant specification.

7.4.2.5 *Effective inductance for radial lead coils (inductance greater than 10 microhenries)* — The test shall be performed as specied in **7.4.2.3.** The inductance shall be as specified in the relevant specification.


BLOCK, LUCITE, PLEXIGLAS OR EQUAL
BIRNBACH # 400 PLUGS OR EQUAL
23·62
25·40
50·80
TEST CLIPS (SEE DETAIL IN FIG.7)
15·87
22·23
6·35
SHALL BE USED WHEN COIL BODY LENGTH IS 14·30 mm OR LESS

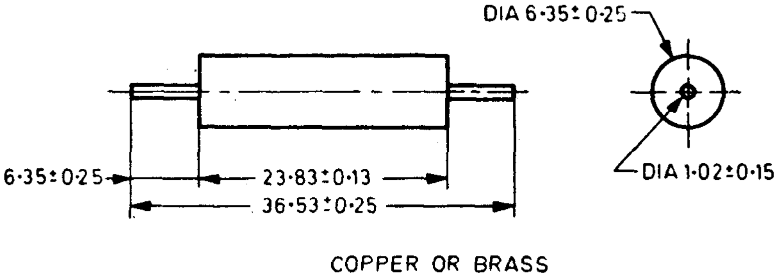
All dimensions in millimetres.

FIG. 3 TEST FIXTURE TF-A (FOR AXIAL LEADS)


BIRNBACH #400 PLUGS OR EQUAL
COPPER-STRIP BRIDGE 6·35
76·20
49·22
25·40
TEST CLIPS (SEE DETAIL IN FIG.7)
15·87
22·23
6·35
SHALL BE USED WHEN COIL BODY LENGTH IS GREATER THAN 14·39mm

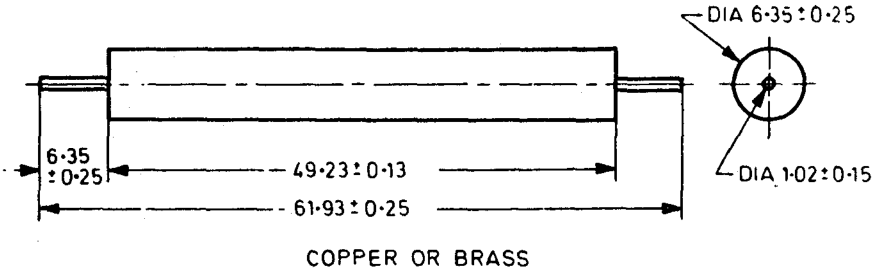
All dimensions in millimetres.

FIG. 4 TEST FIXTURE TF-B (FOR AXIAL LEADS)



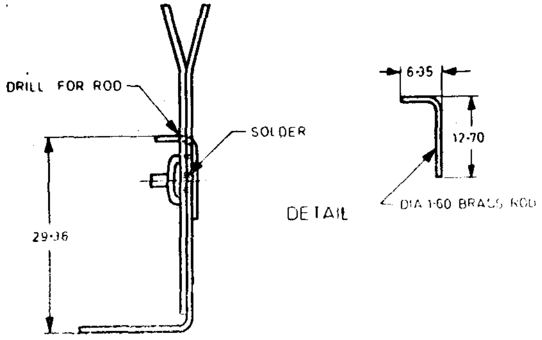
All dimensions in millimetres.

Fig. 5 Shorting Bar for Test Fixture TF-A (for Axial Leads)



All dimensions in millimetres.

Fig. 6 Shorting Bar Test Fixture TF-B (for Axial Leads)



All dimensions in millimetres.

Fig. 7 Test Fixtures TF-C, TF-D and TF-E (for Radial Leads)

7.4.3 *Magnification Factor, Q* — The test shall be performed using a Q-meter. The frequency dial of the Q-meter shall be suitably calibrated and the Q-standard within ± 0·1 percent of the applicable test frequency. Frequencies to be used for testing the various ranges of inductance shall be as specified. The appropriate test fixture as applicable, as shown in Fig. 3, 4 or 7, shall be assembled to the coil terminations of the Q-meter, with the side shown in the test fixture letter facing the capacitance terminations. The unit under test shall then be inserted into the test clip in such a manner that the leads are straight and rest firmly against the stop, and the unit is centred between the terminations. The *Q* shall then be read on the Q-meter.

The value of *Q* shall be as specified in the relevant specification.

7.4.4 *Coupling*

7.4.4.1 *Coupling coefficient* — The coupling coefficient shall be measured using an impedance bridge, or equivalent, at the frequency specified, and ac test voltage shall be the lowest voltage across the coil which will permit the bridge to operate satisfactorily. When the coupling coefficient is greater than 0·9, the open and short-circuited method shall be used. When the coupling coefficient is equal to or less than 0·9, the series aiding series bucking method, or a mutual inductance bridge, shall be used, on the same inductance range and same voltage level. Units having variable coupling shall be measured at the specified extreme of the coupling range, and units having permeability tuning shall be measured, at the middle and at the specified end points of the tuning range. The coupling coefficient shall be calculated as:

$$\text{Coupling coefficient} = \frac{M}{\sqrt{L_1 L_2}}$$

where

$M = \frac{L_1 - L_2}{4}$ = coefficient of mutual inductance (μH),

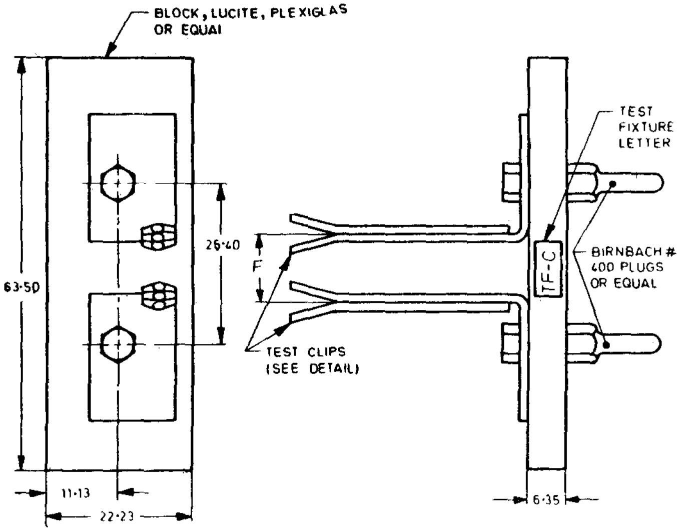
L_1 = total inductance series aiding (μH), and

L_2 = total inductance series bucking (μH)

The inductance values L_1 and L_2 in micrenohries are the measured values of the two coils under measurements at the specified frequency given in Table 5.

TABLE 5 TEST FREQUENCY

(*Clause* 7.4.4.1)



INDUCTANCE µH	TEST FREQUENCY kHz
Less than and equal to 1	100
1 to 100	10
Above 100	1

The coupling coefficient shall be as specified in the relevant specification.

7.4.4.2 *Coupling coefficient* (*alternate method*) — The coupling coefficient between two radio frequency coils is to be determined by measuring the voltage induced in a coil when a voltage is applied to an adjacent coil. In order to maintain reasonable impedance levels, the measurement is to be performed at 100 kHz for nominal inductances of 10 µH or less, at 10 kHz for nominal inductances less than or equal to 100 µH but greater than 10 µH and at 1 kHz for inductances greater than 100 µH. The measurement circuit is shown in Fig. 8.

Equipment for 1kHz and 10 kHz consists of H.P. Model 200 audio oscillator and Model 400 vacuum tube voltmeter; for 100 kHz, Model 606 signal generator and Model 400 vacuum tube voltmeter, or equivalent.

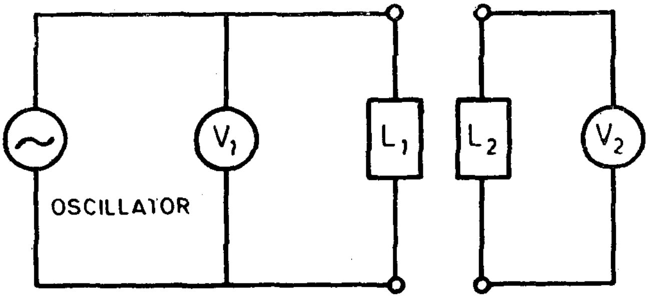


FIG. 8 TEST CIRCUIT FOR COUPLING COEFFICIENT

The coils to be tested shall be taped or otherwise secured, such that the bodies of the coils are kept parallel and in contact with each other to insure maximum coupling. The voltage levels shall be as low as possible to permit reliable reading of V_2. The inductance L should be measured at the same voltage level so that any saturation effect is taken into account.

The coupling coefficient is to be calculated using the equation:

$$\text{Coupling coefficient} = \sqrt{\frac{L_1 V_2}{L_2 V_1}}$$

where

L_1 = effective inductance of primary coil (measured at test frequency),

L_2 = effective inductance of secondary coil,

V_1 = voltage measured across primary, and

V_2 = voltage measured across secondary.

NOTE — This test may also be performed using the Q-meter for the oscillator at the standard test frequency, allowing simultaneous reading of L_1. Reversing the coils allows reading of L_2 and also a second measurement of coupling for verification or averaging.

The coupling coefficient (when $V_1 = 0{\cdot}02$) is to be calculated using the equation:

$$\text{Coupling coefficient} = \frac{50\,V_2}{Q}\sqrt{\frac{L_1}{L_2}}$$

where

L_1 = effective inductance of primary coil (measured at test frequency),

L_2 = effective inductance of secondary coil,

V_2 = voltage measured across secondary, and

Q = as measured.

The coupling coefficient shall be as specified in the relevant specification.

7.4.4.3 The coupling factor for which *Rd* measurements are made (*see* **7.4.8.3**) shall be calculated as follows:

$$F_c = \frac{Rd_p}{Rd_{ps}} = 1 + \frac{K^2}{K_c^2} = 1 + K^2 Q_p Q_s$$

where

F_c = coupling factor,

K = actual coefficient of coupling,

K_c = coefficient at critical coupling,

Q_p = Q of the primary, and

Q_s = Q of the secondary.

The coupling factor shall be as specified in the relevant specification.

7.4.5 *Incremental Current Inductance Reduction* — Incremental current inductance change is the dc current required to cause a change from the inductance measured with zero dc current and the inductance measured with the specified value of incremental current. The test shall be performed using an equipment, incremental bridge or equivalent, at 10 kHz for inductance values between 10 and 100 microhenries and at 1 kHz for inductance values greater than 100 microhenries, and by using the inductance bridge, or equivalent, at 10 kHz for inductance values less than 10 microhenries.

The ac test voltage for incremental current testing shall be the lowest voltage across the coil which will permit the bridge to operate satisfactorily. The inductance of the coil under test with the determined ac test voltage applied shall be measured and recorded with zero dc current in the coil at 1 or 10 kHz, as applicable.

The ac test voltage to be used across the coil for bridge operation, shall be determined by the following formula:

$$E = f\sqrt{L}$$

where

E = voltage (rms) in millivolts,

f = frequency in kHz, and

L = nominal value of inductance in millihenries.

This voltage is to be measured with a vacuum tube voltmeter connected directly across the coil. This voltmeter is disconnected prior to making the inductance measurement. The dc current through the coil shall be adjusted to the value indicated under incremental current for the specific nominal inductance, and with this incremental current flowing through the coil the inductance shall be measured and recorded.

The inductance value shall represent a reduction of 5 percent or less than the inductance measured with zero dc current.

7.4.6 *Effective Parallel Resistance* — In this test, the oscillator controls shall be set at the specified measuring frequency, followed by the insertion of a suitable work coil attached to the Q-meter coil terminations and the capacitor adjusted for resonance. The capacitance-dial reading (C_1) and Q-dial reading (Q_1) shall be recorded, along with the 'multiply Q by' meter dial, when it is other than × 1 which is preferable. The coil under test shall be connected to the capacitance, terminations and the resonance restored by adjusting the capacitor. The Q-dial reading (Q_2) with the test coil connected to the Q-circuit shall be recorded. The effective parallel resistance of the inductor is calculated as:

$$R_p = \frac{150\, Q_1\, Q_2}{F\, C_1\, (\, Q_1 - Q_2\,)}$$

where

Q_1 = Q of the Q-circuit alone,

Q_2 = Q of the Q-circuit with the test coil connected to the Q-circuit,

R_p = effective resistance in kilo-ohms,

F = frequency in MHz, and

C_1 = capacitance in picofarads.

The effective parallel resistance shall be as specified in the relevant specification.

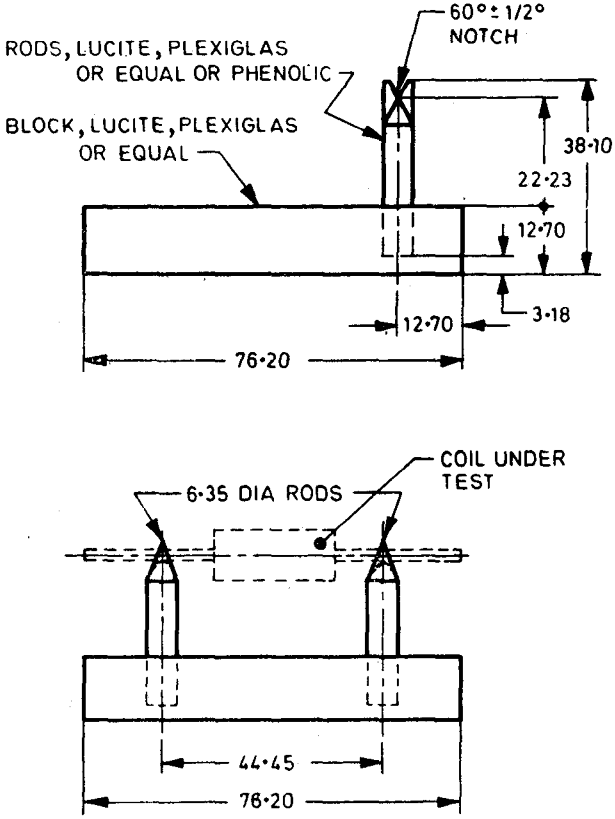
7.4.7 *Self-resonant frequency* — Unshielded coils shall be placed in the field of a variable-frequency oscillator, such as Measurements Corporation Megacycle Meter, Model 59, or equivalent. The oscillator shall include a device for indicating the relative amount of power absorbed from the field (for example a grid-dip meter). The unit under test shall be placed on the appropriate test fixture shown in Fig. 9 or 10. Units shall be suspended or supported at a minimum of 38 mm from any surface other than the test fixture supports or oscillator coil. The frequency of the oscillator shall be varied through the frequency specified. At any frequency in the frequency range, where an abrupt increase in power absorption is indicated, the coupling between the oscillator coil and the unit under test shall be decreased by increasing the separation between the coils, until a moderate dip in grid current results when tuning to this resonance.

This frequency shall be considered the self-resonant frequency of the unit, and shall be accurately determined by suitable means to within ± 0·2 percent. A check shall be made for surplus indications due to a resonance not associated with the unit under test by removing the unit from the field (at frequencies below 2·5 MHz, any suitable method may be used). Coils which cannot be resonated in this manner shall be tested as specified in **7.4.7.1**. Shielded coils shall be tested in a similar manner. However, when electrostatic shielded coils are tested, the shield of the coil shall be grounded.

The self-resonant frequency shall not be less than 90 percent of the self-resonant frequency specified. However, when a minimum value of the self-resonant frequency is specified, the minimum value shall govern.

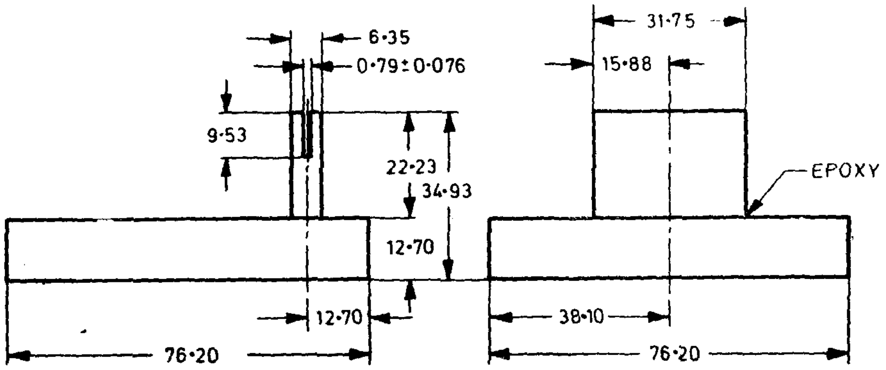
7.4.7.1 *Alternate test method* — When units under test cannot be resonated by the method specified in **7.4.7**, the test shall be performed using a suitable Q-meter. The units shall be mounted in a appropriate test fixture, as applicable, as shown in Fig. 3, 4 or 7, with the test fixture letter facing the inductance terminations. The tuning capacitor of the Q-meter shall then be set to approximately 400 pF, and the Q-circuit shall be resonated by adjusting the oscillator frequency of the Q-meter. The unit under test shall then be placed with a coil that will be resonated in the Q-circuit at a frequency about 10 times the initial resonant frequency, and the Q-circuit shall then be resonated at this new frequency. (This factor of 10 is based on the distributed capacitance of the unit under test being in the region of 4 pF, which is common for small coils. Higher distributed capacitance will lower the resonant frequency of the unit under test, and a factor smaller than 10 will prevail.) The unit under test shall then be connected across the capacitance terminations of the Q-meter taking care to avoid coupling between the unit under test and the comparison coil. The Q-circuit shall then be re-resonated by means of the Q-tuning capacitor or the vernier-tuning capacitor, observing whether the capacitance has to be increased or decreased from its previous value, in order to restore resonance. If the capacitance has to be increased, the oscillator frequency shall be increased by 10 to 20 percent. If the capacitance has to be decreased, the oscillator frequency shall be decreased by the same amount. The unit under test shall then be disconnected from the Q-meter, and the Q-circuit shall be resonated to the new frequency by means of the Q-tuning capacitor. The previous procedure shall then be repeated, while at the same time changing the oscillator frequency by smaller increments as it approaches the resonant frequency of the unit under test, until the frequency reaches a value at which the Q-circuit capacitance is unchanged when the unit under test is connected or disconnected. The self-resonant frequency of the unit under test will then be the frequency of the oscillator and shall be accurately determined to within ± 0·2 percent.

The self-resonant frequency shall not be less than 90 percent of the self-resonant frequency specified. However, when a minimum value of self-resonant frequency is specified, the minimum value shall govern.



All dimensions in millimetres.

FIG. 9 TEST FIXTURE FOR SELF-RESONANT FREQUENCY TEST (FOR AXIAL LEADS)



All dimensions in millimetres.

FIG. 10 TEST FIXTURE FOR SELF-RESONANT FREQUENCY TEST (FOR RADIAL LEADS)

7.4.8 *Impedance*

7.4.8.1 *For untuned RF transformer (primary impedance)* — Transformers primary impedance shall be as measured with all secondaries loaded with their specified impedances, and with specified dc currents flowing in the windings. The resistance and reactance of the primary shall be measured at the specified input frequency and voltage by a bridge or equivalent method.

The impedance shall be as specified in the relevant specification.

7.4.8.2 *For variable-frequency units* — The impedance of variable-frequency transformers shall be measured using an impedance bridge, or equivalent, at the frequency specified.

The impedance shall be as specified in the relevant specification.

7.4.8.3 *For fixed-tuned, resonant units* — The impedance of fixed-tuned, resonant transformers shall be measured using an impedance bridge, or equivalent, at the frequency specified. When specified, the following measurements shall be made:

R_d = anti-resonant impedance;

R_{ds} = anti-resonant secondary impedance with primary short-circuited;

R_{dp} = anti-resonant primary impedance with secondary short-circuited; and

R_{dps} = anti-resonant primary impedance with secondary unterminated, but resonated to the specified frequency.

The impedance shall be as specified in the relevant specification.

7.4.9 *Band Width and Gain* — When specified, the bandwidth and gain of transformers shall be measured at the points specified, using the specified circuit.

NOTE — The use of ' insertion loss ' rather than ' gain ' is preferred. The word ' gain ' has no meaning in a passive device. The test procedure for insertion loss is a matched condition; the test is performed in circuitry and is repeatable.

The bandwidth and gain shall be as specified in the relevant specification.

7.4.10 *Voltage Transfer Ratio*

7.4.10.1 *Setting the variable element of single tuned IF transformer* — The IF transformer winding with the associated condenser is coupled to the RF signal generator and the electronic voltmeter as shown in Fig 11. The frequency of the signal generator shall be adjusted to the IF frequency. By adjusting the variable element (the core of the winding or the condenser) the circuit is tuned to resonance by obtaining maximum deflection on the electronic voltmeter.

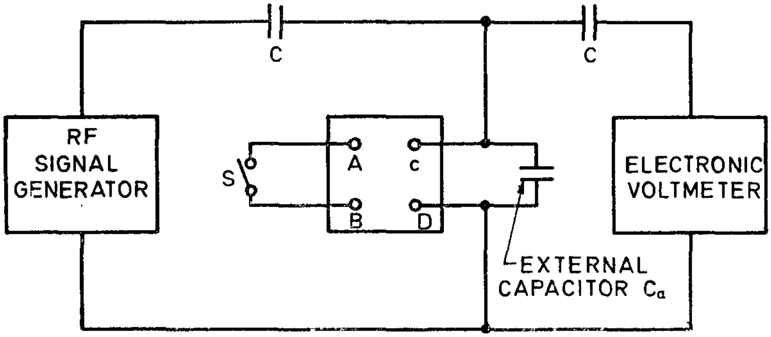


FIG. 11 SET-UP FOR MEASUREMENT OF COUPLING FACTOR *k*

7.4.10.2 *Setting the variable element of RF coils* — The RF coil (where inductance is variable), with a recommended external capacitance, is coupled to the RF signal generator and electronic voltmeter as shown in Fig. 12. The frequency of the signal generator is set to the value at which the coil is operated during normal usage. By adjusting the core the circuit is tuned to resonance by obtaining the maximum deflection on the electronic voltmeter.

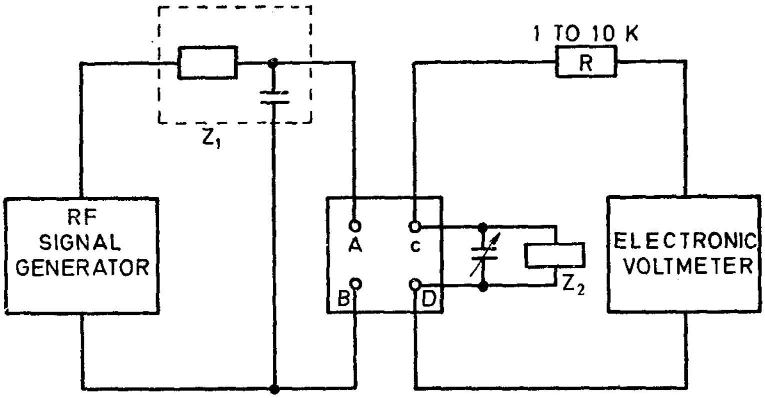


Fig. 12 Set-up for Setting the Variable Element

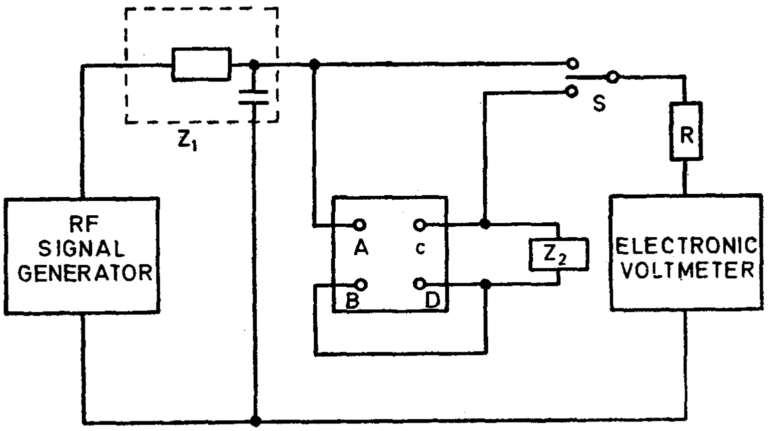
Setting the variable element of the double tuned IF transformer — The IF transformer, terminated with the specified external impedances, is connected, with the first circuit to be tuned coupled to the RF signal generator, as shown in Fig. 12. With the switch ' S ' closed, the variable element of the circuit to be tuned (either the core or the condenser) shall be adjusted for maximum voltage reading on the electronic voltmeter. With the switch ' S ' open, the variable element on the other side is adjusted for the minimum voltage reading on the electronic voltmeter.

Note — The adjustment may have to be done more than once with the switch ' S ' closed and open alternately till final adjustment is arrived at. The core or condenser is then locked in position by wax or by other suitable methods. If this adjustment is disturbed during subsequent measurements, the component shall be set again as detailed.

7.4.10.3 *Voltage transfer ratio measurement* — Voltage transfer ratio is defined as the ratio of the secondary voltage to the primary voltage, under normal operating conditions when terminated with specified external impedances. The set-up for the measurement of voltage transfer ratio is given in Fig. 13. The transformer or coil shall be set up as given in Fig. 13. Z_1 and Z_2 are external impedances recommended by the manufacturer to be used with the transformer or coil. In the case of an aerial coil, Z_1 is the artificial aerial. With the RF signal generator frequency adjusted to the test frequency, the voltage developed across the input and output circuits are measured. The ratio of output voltage to input voltage expressed in dB gives the voltage transfer ratio.

7.4.11 *Continuity of Winding* — Each winding of specimens shall be tested for electrical continuity by any suitable means that will not introduce currents in excess of the rated value.

Each winding shall be electrically continuous.



Z_1 and Z_2 are the internal impedances. R is the isolating resistance whose value shall be such that connecting the electronic voltmeter does not detune the secondary.

FIG. 13 SET-UP FOR THE MEASUREMENT OF VOLTAGE TRANSFER RATIO

7.4.12 *Voltage Proof* — Unless otherwise specified, an ac test potential of frequency 50 Hz shall be applied across the specified points of application. For type approval, the period of application of voltage is one minute and for acceptance test 2 seconds.

The magnitude of the test voltage shall be, unless otherwise specified, as given in Table 6. For voltages greater than 1 000 V, the rate of applications shall not exceed 500 V per second.

7.4.12.1 *Method of mounting* — Specimens shall be mounted by normal mounting means. Cylindrical insulated coils shall be clamped in the trough of a 90 degree noncorrosive metallic V-block of such size that the body of the coil does not extend beyond the extremities of the block. The surface of the V-block shall be free from contamination. The coil leads shall be so positioned that the distance between the leads and any point of the V-block shall be not less than the radius of the coil minus the radius of the lead wire.

7.4.12.2 *Points of application of test voltage* — The test voltage shall be applied between each winding and the case or mounting hardware. Windings not under test shall be grounded to the case or mounting hardware.

Unless otherwise specified, the test voltage shall be applied between the leads of the coil connected together and the V-block.

TABLE 6 VOLTAGE PROOF TEST VOLTAGE AT NORMAL PRESSURE

(*Clause* 7.4.12)

INSULATION WORKING VOLTAGE	RMS TEST VOLTAGE
25 and below	50
25 to 50	100
50 ,, 100	300
100 ,, 175	500
175 ,, 700	2·8 × working voltage
Above 700	1·4 × working voltage + 1 000

7.4.12.3 *At reduced voltage* — The specimens shall be subjected to the voltage proof test specified in **7.4.12** except that the test voltage shall be 90 percent of the values shown in Table 6 and shall be applied for a period of 5 seconds or 75 percent of the values shown in Table 6 applied for a period of one minute.

7.4.12.4 *Two seconds duration* — A proof voltage as specified in Table 6 shall be applied for 2 seconds between the points as stated above for acceptance test.

There shall be no arcing, flashover, breakdown of insulation or other evidence of damage. For IF, RF and discriminator transformer, leakage current shall not exceed in excess of one milliampere.

7.4.13 *Induced Voltage* — Unless otherwise specified, for ac ratings of 25 V rms and above, a voltage sufficient to cause twice the rated voltage to appear across any winding shall be applied. Windings shall be grounded, as they would be in service. The frequency shall be at least twice the minimum frequency of the specified frequency range and shall be remote from any resonant frequency, such that the operational flux density of the core will never be reached. The test potential shall be applied for 5 ± 1 seconds or 7 200 ± 200 cycles, whichever is greater.

There shall be no evidence of continuous arching or breakdown of insulation. Nor shall there be any abrupt changes in the input current or Q, as applicable.

7.4.14 *Insulation Resistance* — Unless otherwise specified, the insulation resistance shall be measured with the application of dc test voltages given in Table 7 for a period of one minute ± 5 seconds.

7.4.14.1 *Points of measurements* — Unless otherwise specified, measurements shall be made between insulated points.

a) For cylindrical coils, the measurements shall be made between the coil winding and the metal strap in the coil-connecting assembly as shown in Fig. 14.

b) Measurements shall be made between mutually insulated points. Each winding shall be tested with all other windings connected together and to the shield.

The insulation resistance shall not be less than 100 mega-ohms.

TABLE 7 INSULATION RESISTANCE TEST VOLTAGE

Maximum Insulation Working Voltage	DC Test Voltage
25 and below	50
25 to 175	100
Above 175	500

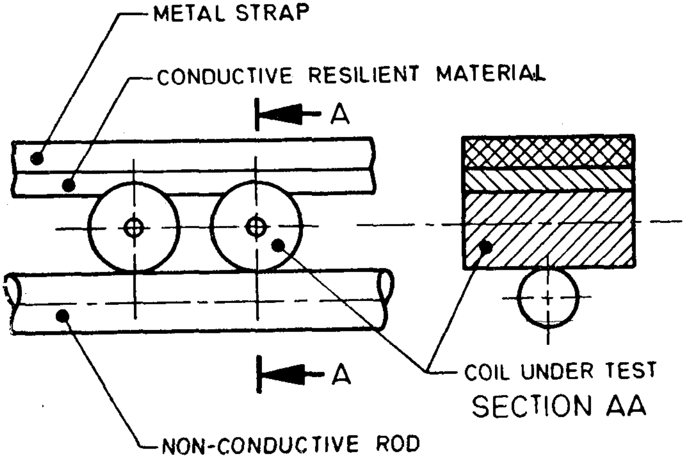


Fig. 14 Coil-contacting Assembly for Mounting During Polarization

7.4.15 *Overload* — A dc current equivalent to one and a half times the specified rated current shall be applied to the windings for 5 minutes.

There shall be no evidence of cracked cases, charred windings, distorted or softened insulation or terminations.

7.4.16 *Bandwidth and Selectivity* — The components shall be adjusted as specified in **7.4.10**. Using the set-up given in Fig. 13, the voltage across the input circuit is measured at resonance frequency f_0. Keeping the output of the RF signal generator constant, the frequency is varied on either side of the resonance frequency till the voltage across the input circuit is $1/\sqrt{2}$ times the voltage at resonance. The frequency difference $\triangle f$ between these two points gives the bandwidth. The frequency of the single generator is further varied on either side of the resonance frequency to the value specified for selectivity limits, and the voltage across the input circuit measured. The ratio of the voltage at resonance to the voltage off resonance expressed in dB gives the selectivity.

7.4.17 *Factor KQ (for Double Tuned IF Transformer)* — The set-up given in Fig. 12 is used for the measurement. The transformer shall be adjusted as described in **7.4.10**. The voltage across the input side of the transformer is measured with the switch ' S ' closed (E_1) and open (E_2). The factor KQ is then given by:

$$KQ = \sqrt{\frac{E_1 - E_2}{E_2}}$$

7.4.18 *Checking the Adjustment Facilities* — The object of this test is to vary the variable element between the maximum and minimum value to ensure the frequency coverage specified. The component shall be tuned as specified in **7.4.10**. The frequency of the RF signal generator shall be set at the maximum frequency specified and the variable element tuned to observe a maximum deflection. Similarly, with the frequency of the RF signal generator set at the minimum frequency specified, the variable element shall be adjusted to observe the maximum deflection.

7.5 Mechanical Tests

7.5.1 *Sealing Test* — In the case of hermetically sealed transformers or coils, the components shall be subjected to sealing test in accordance with Sec 3 (Method 1 or Method 2) or Sec 4 of IS : 9000 (Part XV)-1982*.

In the case of sealing test according to Sec 4 of IS : 9000 (Part XV)-1982*, the duration of conditioning shall be 10 min and there shall be no evidence of leakage of impregnant when examined under ultraviolet radiation.

7.5.2 *Immersion Test*

7.5.2.1 The object of this test is to determine the effectiveness of seals of components when subjected to specified immersion conditions.

7.5.2.2 The components shall be subjected to successive cycles of immersion in suitable hot and cold baths of salt or tap water capable of providing the specified conditions.

NOTE — This procedure may be used to detect a defective terminal assembly, or a partially closed seam or moulded enclosure of a component by subjecting it to alternate thermal stresses.

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*Basic environmental testing procedures for electronic and electrical items : Part XV Sealing test.

7.5.2.3 The components shall be subjected to successive cycles of immersion, each cycle consisting of immersion in hot water bath at a temperature of 65 $^{+5}_{-0}$ °C followed by an immersion in a cold bath. The number of cycles shall be 2 and the duration of each immersion shall be 15 minutes. The cold bath shall contain saturated solution of sodium chloride and water at 25 $^{+10}_{-5}$ °C. The transfer of the components from one bath to the other shall be accomplished as rapidly as practicable.

NOTE — When electrical measurements are made after immersion cycling to obtain evidence of leakage, the use of salt solution instead of tap water will facilitate detection of water penetration.

7.5.2.4 After the test, the components shall be thoroughly and quickly rinsed in tap water and thoroughly dried externally by wiping or by applying a blast of air at atmospheric conditions for testing as required by the relevant component specification. The components shall then remain under recovery conditions for 2 to 24 hours, or as required by the relevant component specification.

7.5.2.5 After recovery, the component shall be visually examined. There shall be no visible damage or mechanical deterioration. The components shall also be subjected to insulation resistance tests and high voltage test in accordance with **7.4.12** and **7.4.14**, respectively. The insulation resistance shall not be less than 100 magohms.

7.5.3 *Solderability* — Transformers and coils provided with tag and lead type terminations shall be subjected to the soldering iron test (Method 3) with a soldering iron of suitable size in accordance with Sec 1 of IS : 9000 (Part XVIII)-1981*. The period of recovery shall be in 10 minutes.

At the end of the test, the component shall be visually examined. It shall not show any loosening of connections, melting or seepage of sealing material or any other deterioration. The countinuity of all the windings shall also be checked.

7.5.4 *Robustness of Terminations* — The test shall be carried out in accordance with IS : 9000 (Part XIX/Sec 1 to 5)-1978*. The loading weight shall be 0·5 kg or equal to the weight of the component, whichever is more. The duration of this test shall be 10 seconds. There shall be no evidence of loosening or rupturing of the terminals or other mechanical damage. Bends shall not be considered.

7.5.4.1 *Tensile* — The test shall be carried out in accordance with Sec 1 of IS : 9000 (Part XIX/Sec 1 to 5)-1978*.

a) *Wire and tag termination* — The loading shall be specified in the relevant detail specification and the force shall be applied in any direction including the weakest.

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*Basic environmental testing procedures for electronic and electrical items :
Part XVIII Solderability test.
Part XIX Test for robustness of terminations and integral mounting devices.

b) *Printed circuit and pin-type termination* — The terminations shall be tested by gradually applying a force of 11 N to each termination in the direction of the axis of the terminations. Except for flexible leads, there shall be no rotation of flexible terminals.

7.5.4.2 *Bending* — The test shall be carried out in accordance with Sec 3 of IS : 9000 (Part XIX/Sec 1 to 5)-1978*.

a) *Wire termination* — The terminal components shall be tested by gradually applying a force equal to half of that specified in **7.5.4.1**, or any other value specified.

NOTE — This test is applicable to solid-wire lead terminations of limited ductility, such as nickel-alloy type lead and those used in hermetically sealed component parts.

b) *Tag and strip* — The terminations shall be tested 5 times through an angle of 90 degrees (45 degrees each side of the centre). Any terminal that shows permanent deformation greater than 15° of the metal portion of the terminal in the terminal tensile test as given in **7.5.4.1** shall be tested. This test does not apply to terminals which shows permanent deformation, but are not designed to bent 45 degrees.

7.5.4.3 *Tortion* — The test shall be carried out in accordance with Sec 4 of IS : 9000 (Part XIX/Sec 1 to 5)-1978*.

a) *Axial wire terminations (other than printed terminations)* — The body of the component part or the clamped terminal shall be rotated through 360 degrees about the original axis of the bent terminal, in alternating directions, for a total of 5 rotations, at the rate of approximately 3 seconds per rotation.

7.5.4.4 *Torque* — The test shall be carried out in accordance with Sec 5 of IS : 9000 (Part XIX/Sec 1 to 5)-1978*.

a) *Screw thread terminations* — The torque shall be applied to the terminal at the point where the external lead wires are normally connected to it. The motion shall be applied clockwise and counter-clockwise in a plane perpendicular to the axis of the terminal. The equivalent diameter is equal to two times the distance from the terminal centre to the point of wire connection after the maximum permanent deflection has taken place due to the tensile test given in **7.5.4.1**. The equivalent diameter for 'hook' type terminals is the diameter of the wire from which the terminal is formed.

7.5.4.5 The continuity of all windings shall be checked after this test.

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*Basic environmental testing procedures for electronic and electrical items: Part XIX Test for robustness of terminations and integral mounting devices.

7.5.5 *Vibration Test* — The transformer or the coils shall be subjected to vibration test in accordance with IS : 9000 (Part VIII)-1981* to the severity specified. The transformer or the coils, shall be mounted, taking care that the terminations are not stressed and that equal number of samples are vibrated along each of the three principal axes.

Each specimen shall be monitored to determine electrical discontinuity by a method which shall at least be sensitive enough to monitor or register automatically any electrical discontinuity of 0·1 milliseconds or greater duration.

After the test, the samples shall be visually examined and shall show no apparent damage or deterioration. The continuity shall also be checked.

7.5.6 *Bump Test* — The transformers and coils shall be subjected to the bump test in accordance with Sec 2 of IS : 9000 (Part VII/Sec 1 to 5)-1979*. The samples shall be mounted as specified in **7.5.4** and in such a manner that equal number of samples are bumped in each of the three principal axes.

After the test, the component shall be visually examined and shall not show any apparent damage or deterioration. The magnification factor shall be measured and shall conform to the specified value.

7.5.7 *Core Rotation Torque* — Where the core is held in place in the coil by a spring arrangement, the torque required to rotate the core shall be within 20 to 350 g/cm.

7.6 Climatic Tests

7.6.1 *Climatic Sequence*

7.6.1.1 *Dry heat* — The components shall be subjected to this test in accordance with Sec 5 of IS : 9000 (Part III/Sec 1 to 5)-1977*, the temperature of the test chamber being maintained at the appropriate maximum value for the category.

At the end of the period of conditioning and while still at the high temperature, the insulation resistance shall be measured in accordance with **7.4.14**.

The components shall then be removed from the dry heat chamber and allowed to remain under standard recovery conditions.

After recovery, the components shall be visually examined. There shall be no damage or deterioration.

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*Basic environmental testing procedures for electronic and electrical items :
Part VIII Vibration.
Part VII Impact test.
Part III Dry-heat test.

The insulation resistance shall be measured after recovery and shall not be less than 100 megohms. The magnification factor Q shall be measured after the test and this shall conform to the specified value.

7.6.1.2 *Damp heat* (*cyclic*) (*first cycle*) — The components shall be subjected to the first cycle of this test in accordance with Sec 2 of IS : 9000 (Part V)-1981*. After the specified period of conditioning, the components shall be removed from the chamber and allowed to remain under standard recovery conditions for a period of one and a half hours.

After recovery, the components shall be visually examined. There shall be no visible damage or mechanical deterioration. The marking shall be legible.

7.6.1.3 *Cold* — The components shall be subjected to this test in accordance with Sec 4 of IS : 9000 (Part II)-1977*, the temperature of the chamber being maintained at the appropriate value for the category of components under test. The duration of exposure shall be 2 hours. After the specified period of conditioning, the components shall be removed from the chamber and allowed to remain under standard recovery conditions for a period of 2 hours.

After recovery, the components shall be visually examined. There shall be no visible damage or mechanical deterioration. The insulation resistance shall be not less than 100 megohms. The magnification factor Q shall be measured and this shall conform to the specified value.

7.6.1.4 *Low air pressure* — The components shall be subjected to this test in accordance with IS : 9000 (Part XIII)-1981*, the test chamber being maintained at a pressure appropriate to the category of the components. The duration of the exposure shall be 5 minutes.

During the period of exposure, a test voltage equal to 120 percent of the working voltage shall be applied across the primary under the following conditions:

a) All secondary windings shall be open-circuited, and

b) If any winding(s) of the transformer is (are) specified for working with a dc or ac voltage between the windings or core, case or other windings, 120 percent of this voltage shall be applied between the windings and other appropriate points.

In the case of coils, the high voltage test shall be carried out in accordance with **7.4.12.** During and after this test, there shall be no sign of glow, discharge, breakdown or flashover.

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*Basic environmental testing procedures for electronic and electrical items:
Part V Damp heat (cyclic) test.
Part II Cold test.
Part XIII Low air pressure test.

7.6.1.5 *Damp heat* (*cyclic*) (*remaining cycles*) — The components shall be subjected to the remaining number of cycles of this test in accordance with Sec 2 of IS : 9000 (Part V)-1981*.

After the specified period of conditioning, the components shall be removed from the chamber and allowed to recover under recovery conditions appropriate to this test.

After recovery, the components shall be visually examined. There shall be no visible damage or mechanical deterioration. The marking shall be legible. The insulation resistance and voltage proof (high voltage) tests shall be carried out in accordance with **7.4.14** and **7.4.12**. The insulation resistance shall not be less than 100 megohms.

After a further period of recovery of 24 hours, the insulation resistance shall be measured in accordance with **7.4.14** and shall not be less than 100 megohms.

The magnification factor Q shall be measured and shall conform to the specified value.

7.7 Damp Heat (Steady State) — The components shall be subjected to this test in accordance with IS : 9000 (Part IV)-1979*. The duration of the exposure shall be appropriate to the category of the components. During exposure, the normal polarizing voltage to which the components will be subjected in the actual usage shall be applied. After the specified period of conditioning, the components shall be removed from the chamber and allowed to recover under recovery conditions appropriate to this test.

After recovery, the components shall be visually examined. There shall be visible damage or mechanical deterioration. Marking shall be legible. The insulation resistance shall be measured in accordance with **7.4.14** which shall not be less than 100 megohms.

After a further period of recovery of 24 hours, the insulation resistance shall be measured in accordance with **7.4.14** and it shall not be less than 100 megohms.

The magnification factor Q shall be measured after the test and this shall conform to the specified value.

7.8 Change of Temperature — This test shall be carried out in accordance with Sec 1 of IS : 9000 (Part XIV)-1978*. The maximum and minimum temperatures shall be appropriate to the category of the components. The total number of cycles shall be 5. The period of exposure to both maximum and minimum temperature shall be one hour each.

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*Basic environmental testing procedures for electronic and electrical items:
Part V Damp heat (cyclic) test.
Part IV Damp heat (steady state).
Part XIV Change of temperature.

After the exposure, the components shall be removed from the chamber and allowed to recover under conditions appropriate to this test. The components shall be visually examined and there shall be no visible damage or mechanical deterioration.

After recovery, the components shall be subjected to high voltage test and insulation resistance test in accordance with **7.4.12** and **7.4.14**, respectively. The insulation resistance shall not be less than 100 megohms.

7.9 Salt Mist — The components shall be subjected to salt mist test in accordance with **7.10** of IS : 589-1961*, the period of exposure shall be 4 days.

After the specified period of conditioning, the components shall be removed from the chamber and allowed to recover under recovery conditions appropriate to this test.

After recovery and cleaning, the components shall be visually examined. There shall be no corrosion or machanical deterioration or any other visible damage. The marking shall be legible. The continuity of all windings and the robustness of terminations shall be checked.

7.10 Mould Growth — The components shall be subjected to this test in accordance with IS : 9000 (Part X)-1979†.

After the expiry of the specified period of exposure, there shall be no mould growth on the components visible to the naked eye.

7.11 Endurance — The components shall be operated at the maximum category temperature for the rated voltage and frequency for 2 000 hours. The loads shall be those for which the component is designed. After completion of the specified duration of operation, the transformer or coil shall be exposed to recovery conditions for 24 hours and shall be subjected to the following tests:

a) *Visual examination* — There shall be no deterioration so as to impair operations and the markings shall be legible.

b) *Insulation resistance* — The values shall be not less than those specified in **7.4.14**.

7.12 Temperature Rise — Unless otherwise specified, the temperature rise test shall only be performed on transformers rated at more than 0·8 Watt average output. The temperature rise of cylindrical insulated coils shall be determined as specified in **7.12.1**. The temperature rise of the

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*Basic climatic and mechanical durability tests for components for electronic and electrical equipment (*revised*).

†Basic environmental testing procedures for electronic and electrical items: Part X Mould growth test.

winding of transformers and coils shall be determined by change in resistance method. The test shall be performed at the specified ambient temperature and with rated dc current applied. When specified, an alternating voltage of the frequency and magnitude specified, shall be superimposed on the direct current. When the resistance of the winding, measured at 5-minute intervals, remains constant, the temperature of the winding shall be considered as stabilized. If the method used for determining the resistance of the winding requires the removal of power, the measurement shall be made within 30 seconds after the removal of power.

7.12.1 *For Cylindrical Insulated Coils* — The coil under test shall be connected to a test fixture conforming to Fig. 15 with each wire lead wrapped one turn around the test fixture terminal and shall be soldered to the terminal for uniform low contact resistance. The test fixture, with the attached coil, shall then be placed in a test chamber which allows forced-air circulation to be shut off during test. The test chamber shall be free of test area draughts and direct thermal radiation. A temperature indicating device with an accuracy of ± 0·5 °C shall be located in the area surrounding the coil under test, but no where it will be influenced by the temperature rise of the coil. The test chamber temperature shall than be stabilized at the specified ambient temperature. The dc resistance (r) shall be measured with one-tenth rated dc applied at the specified ambient temperature (t).

When the resistance of the coil is stabilized, the resistance value shall be recorded. The ammeter-voltmeter method may be used for determining this resistance, provided that the accuracy of these metres is ± 0 5 percent or better and the resistance of the voltmeter is at least 1 000 ohms per Volt. The rated dc shall then be applied to the coil under test, using a stable current source such as a storage battery. Forced-air circulation shall be shut off when rated current is applied. When the resistance of the specimen under test is stabilized with rated current applied, the resistance (R) and the test chamber temperature (T) shall be recorded. The temperature rise ($\triangle T$) shall be calculated as:

$$\triangle T = \frac{R - r}{r} (t + 234{\cdot}5) - (T - t)$$

where

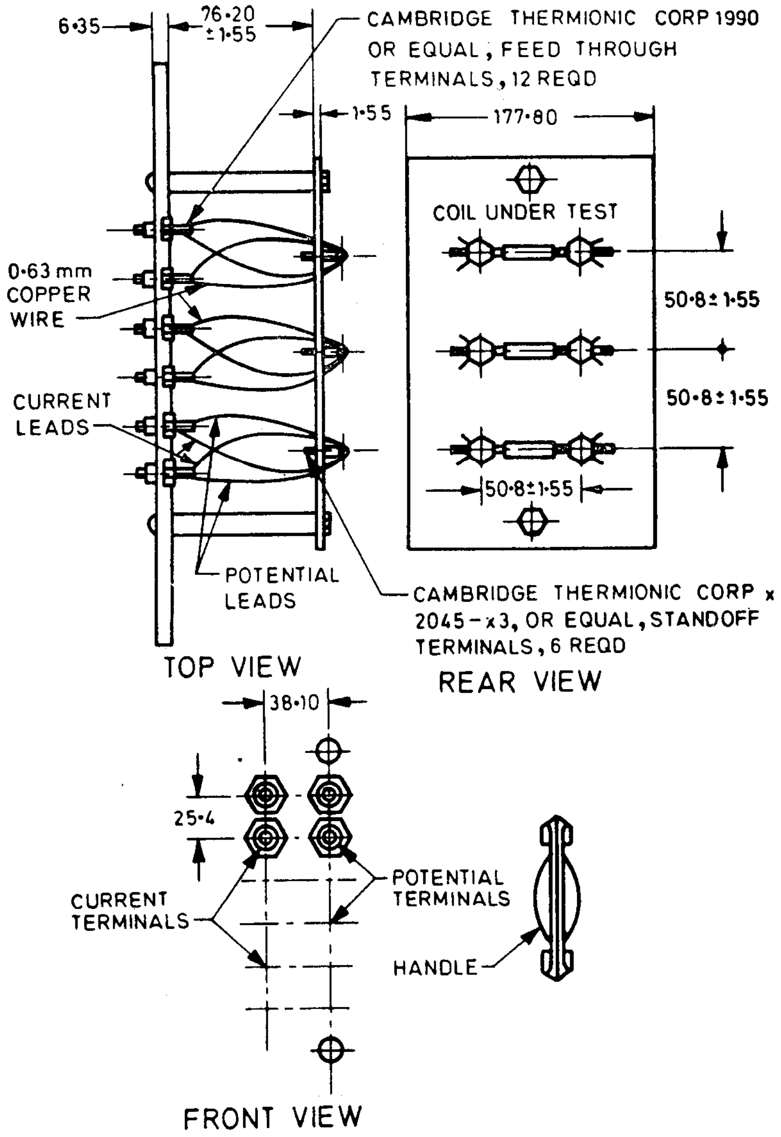
$\triangle T$ = temperature rise in °C above the specified ambient temperature,

R = resistance of winding (in ohms) at temperature ($T + \triangle T$),

r = resistance of winding (in ohms) at temperature (t),

t = specified initial ambient test chamber temperature (in °C), and

T = maximum ambient test chamber temperature (in °C) at the time of power shut off. T shall not differ from it by more than 5 °C.



All dimensions in millimetres.

FIG. 15 TEST FIXTURE FOR TEMPERATURE RISE ON INSULATED COILS

There shall be no evidence of physical damage. The temperature rise of any winding above the specified maximum ambient temperature shall not exceed the value specified.

7.13 Flammability — The test shall be carried out in accordance with the procedure given in Appendix B.

APPENDIX A

(*Clause* 0.4)

INFORMATION TO BE GIVEN BY THE PURCHASER

A-1. The following information shall be furnished by the purchaser with his enquiry or order:

i) Grade;

ii) Category;

iii) Nominal frequency of operation (for IF transformers) or frequency range of operation (for RF coils);

iv) dc resistance;

v) Inductance of the individual winding;

vi) Current rating;

vii) Self-resonance frequency (RF coils);

viii) Required external capacitor values (maximum and minimum);

ix) Magnification factor and the limits of variation during various climatic and mechanical tests;

x) Coupling factor *k* (for aerial coils);

xi) Voltage transfer ratio (or gain factor);

xii) – 3 dB bandwidth and selectivity;

xiii) Adjustment range required;

xiv) Maximum working voltage;

xv) External circuit impedances;

xvi) Whether temperature rise test is applicable:

    a) Maximum ambient temperature,

    b) Maximum allowable temperature rise, and

    c) Characteristics of current to be applied;

xvii) Overload test rated current;

xviii) Applicable measurements for stability at temperature extremes;

xix) Insulation requirements;
xx) Voltage proof voltage:
  a) At normal pressure,
  b) For special design features,
  c) Air pressure (low),
  d) Insulation working voltage;
xxi) Factor *KQ* (for double tuned IF transformer);
xxii) Shielding, if any;
xxiii) Sealing, if any;
xxiv) Overall dimensions and mass;
xxv) Type, mounting and terminations;
xxvi) Length of the leads; and
xxvii) Any other information.

APPENDIX B

(*Clause* 7.13)

FLAMMABILITY TEST

B-1. OBJECT

B-1.1 This test is intended to determine whether components will support combustion.

B-2. TEST CHAMBER

B-2.1 The chamber used for this test shall have the following provisions:

a) An enclosure protected from air currents, but provided with means of venting fumes and admitting an adequate supply of fresh air at the bottom;

NOTE 1 — A metal box about 600 mm wide, 900 mm high and 600 mm deep, with a detachable front, a viewing window and suitable holes for intake of air and venting of fumes shall be used.

NOTE 2 — Adequate safety precautions shall be taken to protect personnel from possible explosion of the components.

b) A suitable stand or support for the components involving a minimum of heat transfer; and

c) A spirit burner of the pattern shown in Fig. 16 or of any other pattern. The fuel for the burner shall be good quality 66° OP industrial methylated spirit containing not more than 5 percent of wood naptha (*see* IS : 324-1959*). The burner and the flame are considered satisfactory if a bare copper wire of 0·71 mm diameter having a free length of not less than 100 mm in the flame in the position to be occupied by component melts in less than 6 seconds.

NOTE — The melting point of copper is 1 083°C.

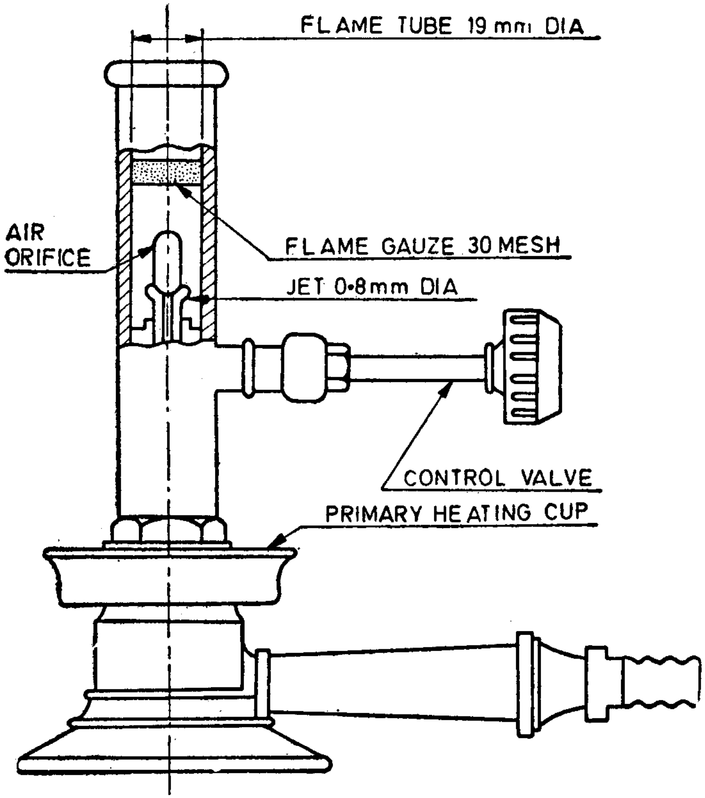


FIG. 16 SPIRIT BURNER

B-3. MOUNTING

B-3.1 The components shall be mounted on the stand placed within the test chamber in such a manner that they are not shielded from the flame

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*Specification for ordinary denatured spirit (*revised*).

by the support. The precise orientation of the components relative to the flame, if not stated in the relevant specifications, shall be that judged to be the most unfavourable or which presents maximum surface to the test flame.

B-3.2 The height of the components shall be so adjusted that the lowest part of the component body is 51 mm from the top of the burner as shown in Fig. 17.

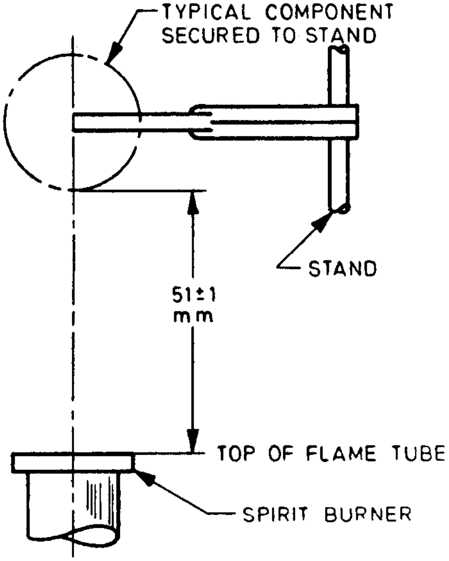

Fig. 17 Relative Position of Burner and Component

B-4. TESTING

B-4.1 After confirming that the flame is satisfactory and as specified in **B-2.1** (c), the burner shall be placed underneath the component in such a manner that they are enveloped by the flame. The component shall be exposed to the flame for either one minute or any less time necessary to cause ignition.

B-4.2 If ignition has occurred, it shall not continue for more than 15 seconds, or any other period specified in the relevant specification, after withdrawal of the flame.

B-5. REQUIREMENT

B-5.1 Burning particles shall not detach from the components.

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